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CONISTON GS
MAIN DAM AND SPILLWAY PIERS
CONCRETE CONDITION SURVEY

Report No. 90-29-K

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ABSTRACT

The concrete in the Coniston GS main dam was evaluated and petrographically examined in 1989. Based on the results of this work, it was decided to undertake further investigation of the structure and to evaluate the potential for further expansion of the concrete due to alkali-aggregate reactivity. The subsequent investigation determined that the concrete on the downstream face of the gravity sections was deteriorated to a depth of up to 480 mm. Beyond this depth, the concrete appeared to be sound. The concrete in the lower portion of the piers investigated appeared to be sound, with the exception of localized cracks. The concrete in the upper portion of the piers was recovered as rubble. Although alkali-aggregate reactions are taking place in the concrete in this dam, deterioration of the surface concrete appears to be accelerated by other factors such as freeze-thaw action. The testing of specimens prepared from the cores for alkali-aggregate reactivity is currently underway and will be reported when complete.

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CONISTON GS
MAIN DAM AND SPILLWAY PIERS
CONCRETE CONDITION SURVEY

E.J. McColm

1.0 INTRODUCTION

The condition of the concrete in the Coniston GS main dam was evaluated in October 1989, and the results were reported in Research Division Report 90-2-K. The area within one metre of the upstream face of the dam was investigated, and the concrete in this area was classified as fair to poor. A petrographic examination of specimens prepared from concrete cores drilled from the main dam in 1989 identified the presence of alkali-aggregate reactivity (Research Division Report S90-16-K). Based on the results of the concrete investigation and the petrographic examination, it was decided that further work should be undertaken to investigate the quality of the concrete in the remainder of the structure, and to evaluate the potential for further expansion of the concrete due to alkali-aggregate reactivity.

The 1990 investigation, which was carried out from June 26 to July 6, consisted of drilling concrete cores from the downstream face of the north and south gravity sections, the spillway piers and the powerhouse. The boreholes were examined with a borehole camera, and specimens prepared from the cores were tested in the laboratory to determine the compressive strength of the concrete in the piers and to evaluate the potential for further expansion of the concrete in the piers and the main dam. The drilling and borehole camera survey were carried out by the Rock Sciences Section, and the laboratory testing was conducted by the Concrete Technology Section of the Civil Research Department.

This report summarizes the results of the investigation carried out in 1990, with the exception of the long-term testing for alkali-aggregate reactivity. These results will be reported in approximately one year when the testing is complete.

2.0 CONCRETE CORING AND OBSERVATIONS

2.1 Gravity Sections

The gravity sections of the main dam were visually inspected, and six 100-mm diameter cores, three (Cores 1 to 3) from the north gravity section and three (Cores 4 to 6) from the south gravity section, were drilled at right angle to the downstream face of the dam to determine the extent of concrete deterioration. Figure 1 shows the extent of deteriorated concrete in the cores, and Appendix A contains the concrete core log.

The downstream face of the dam was covered with efflorescence deposited by water leaking through the concrete (Figure 2). In the areas with the worst leakage, the concrete had extensively deteriorated (Figure 3). In general, the accessible concrete near the base of dam was found to be spalled. Near the top of the dam, the concrete was cracked in the area sheltered by the deck, but did not have extensive deposits of efflorescence or surface deterioration.

The bulge on the surface of the north gravity section, reported in 1989, appeared to have increased in size and was investigated further. The area was sounded with a hammer and found to consist of spalled concrete, affecting the surface to a depth of approximately 100 mm (Figure 4).

The deterioration observed in the cores drilled from the base of the dam (Figure 5) is shown in Figure 1 and extended to a maximum of 480 mm below the surface of the dam. Beyond this depth, the concrete appeared sound.

The composition of the concrete in the cores was similar to that reported during the previous inspection (Research Division Report 90-2-K). Petrographically the concrete was similar to that evaluated previously (Research Division Report S90-16-K). Cracks were present through the aggregates, and many of the small voids (maximum 5 mm) in the concrete were filled with a white deposit. Core breaks occurred through and around the aggregates. The cores were retrieved in good condition, except for the sections near the surface of the dam, which were recovered as rubble.

2.2 Spillway Piers

Three cores (Cores 7 to 9) were drilled vertically from the piers. Core 7, 100 mm in diameter, was drilled to bedrock, and the retrieved core is shown in the concrete core log in Appendix A. The other two cores (Cores 8 and 9) were drilled to accommodate the borehole camera and the cores were not retained. The results of the borehole camera survey are summarized in Appendix A.

Core 7 was retrieved in good condition, except for the top 480 mm which was cracked or recovered as rubble. The concrete in this core was similar in composition and petrographically to that in the cores from the gravity sections.

2.3 Powerhouse

The two 100-mm diameter cores (Cores PH1 and PH2) drilled from the floor of the powerhouse are described in the concrete core log. These cores were drilled to provide reference specimens for the alkali-aggregate reactivity testing of the concrete from the main dam, and no attempt was made to evaluate the quality of the concrete in the powerhouse. The cores consisted primarily of large stones bonded together with mortar. The mortar contained a large number of small voids, up to 5 mm in size. A poor bond was observed between the mortar and a few of the large stones.

3.0 BOREHOLE CAMERA SURVEY

The video of the borehole camera survey is stored with the Concrete Technology Section, and a copy was forwarded to the Civil Maintenance Department. The survey of the six holes drilled from near the base of the gravity sections identified numerous cracks in the concrete near the downstream face of the dam. Below the surface deterioration, the concrete appeared sound.

The survey of the three holes drilled vertically into the piers identified a few localized cracks up to approximately 15 mm in width (Appendix A). Cracked aggregates and small hairline cracks were also noted in the concrete and appeared more prominent near the top of the holes.

The holes drilled in the powerhouse were not examined with the borehole camera.

4.0 LABORATORY TESTING

4.1 Compressive Strength and Density

Specimens prepared from Core 7 drilled from a spillway pier were tested for compressive strength (CAN/CSA - A23-2-14C) and density. The test results are summarized in Table 1. This testing was carried out to compare the physical properties of the concrete in the piers with those of the concrete from the upstream face. The compressive strength and density averaged 32.8 MPa and 2454 kg/m^3, respectively, compared with average values of 19.4 MPa and 2428 kg/m^3 for specimens previously tested from the upstream face of the main dam (Research Division Report 90-2-K).

4.2 Alkali-Aggregate Reactivity

Laboratory testing has been initiated to determine the potential of further expansion of the concrete due to alkali-aggregate reactivity. Specimens prepared from the cores drilled from the gravity sections and one of the spillway piers are stored at 38°C and 100% relative humidity and are being monitored for length change for a 12-month period. Specimens are also being tested using the Split Core test procedure. This test consists of cutting of a core longitudinally into two equal sections and placing one half in a lime water solution and the other half in a 1 M NaOH solution. The change in length of the specimens is then measured periodically. The monitoring of the specimens will be carried out for approximately one year, at which time the results of these tests will be reported.

Suitable test specimens could not be prepared from the cores drilled from the powerhouse because the cores consisted primarily of large stones bonded together with mortar. The composition of these cores was not similar to that of the concrete in the main dam.

5.0 CONCLUSIONS

a) Based on the concrete coring from the downstream face at the base of the gravity sections, the deteriorated concrete in these areas appeared to extend to a depth of 480 mm below the surface of the dam. The concrete beyond this depth appeared to be sound.

b) The core drilled from one of the spillway piers and the results of the borehole camera survey indicated that the concrete in the areas drilled was generally sound, with the exception of deteriorated concrete near the top of the dam and a few localized cracks in the structure. The compressive strength and density of specimens obtained from a core drilled from one of the spillway piers averaged 32.8 MPa and 2454 kg/m^3, respectively.

c) As determined previously, alkali-aggregate reactions are occurring in the concrete in this dam. It appears that the deterioration of the concrete at the surface of the dam has been accelerated by other factors such as freeze-thaw action. The testing of specimens prepared from the cores drilled from the main dam and a spillway pier for alkali-aggregate reactivity is currently underway and will be reported when the testing is complete.

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TABLE 1

CONISTON GS
SPILLWAY PIER
RESULTS OF LABORATORY TESTS ON CONCRETE CORES (See Notes)

Specimen Number	Depth in Borehole (m)	Max Size of Aggregate (mm)	Compressive Strength (MPa)	Density (SSD) (kg/m^3)
Core 7				
1-1	1.50	20	32.5	2431
1-2	2.00	20	41.4	2444
1-3	3.20	20	44.4	2453
Avg			39.4	2443
2-1	6.55	20	22.1	2468
2-2	7.80	20	24.0	2445
2-3	8.85	20	30.0	2456
Avg			25.4	2456
3-1	10.20	25	33.0	2469
3-2	10.50	25	36.5	2462
3-3	11.90	25	31.2	2456
Avg			33.6	2462
Avg (of all test results)			32.8	2454

Notes:

1. Compressive Strength: specimen in Saturated Surface Dry (SSD) condition. Specimen tested in accordance with CSA CAN3-A23.2-14C. Specimen diameter - 100 mm.

2. Density SSD: specimen in Saturated Surface Dry (SSD) condition.

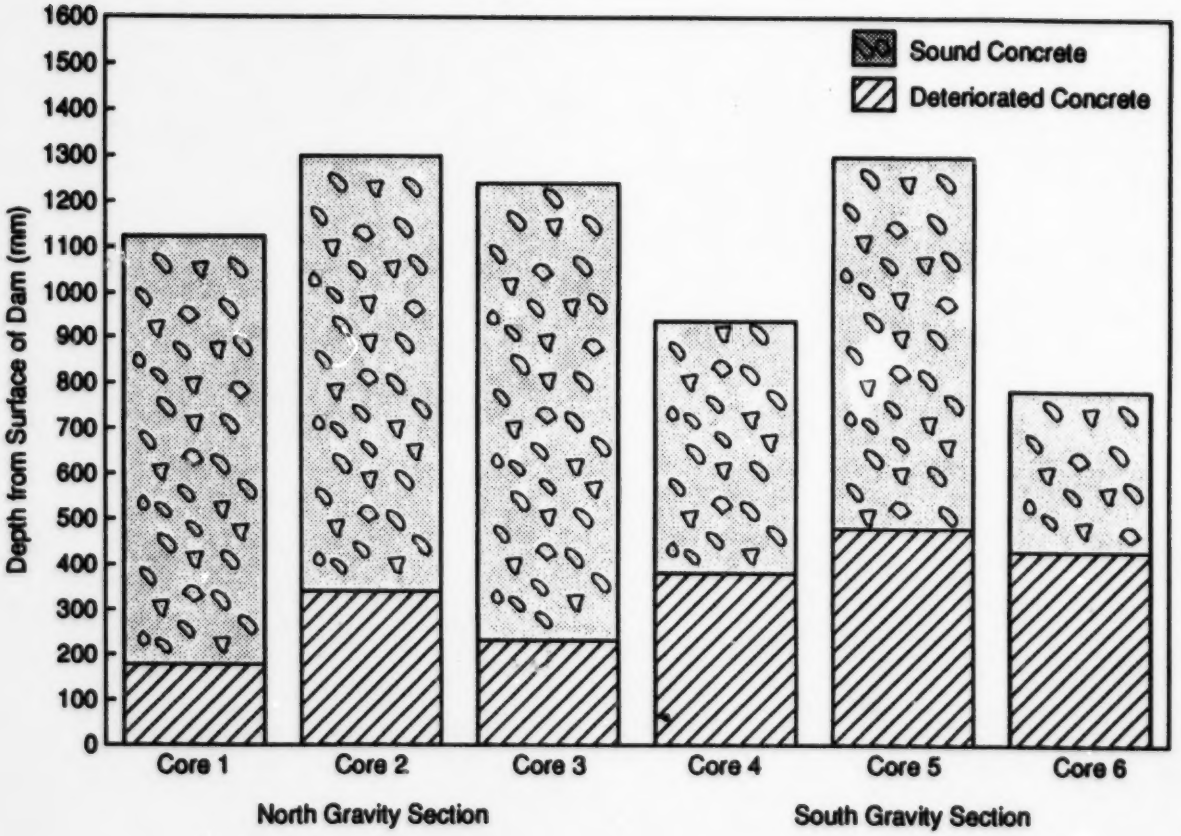

FIGURE 1

CONISTON GS
MAIN DAM - GRAVITY SECTIONS
EXTENT OF CONCRETE DETERIORATION OBSERVED IN CORES

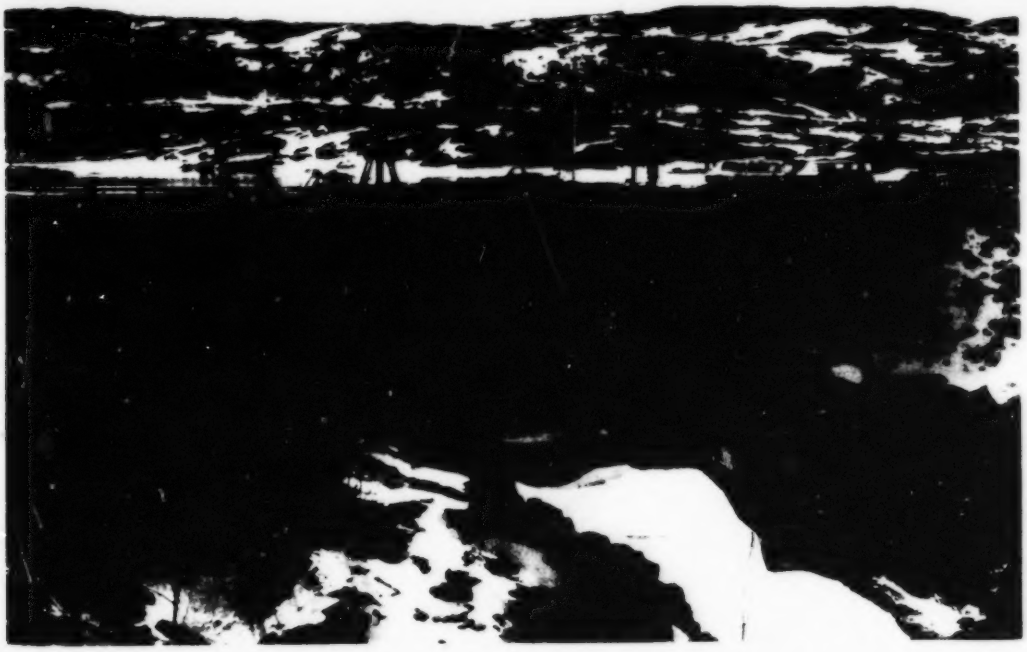

Figure 2 Downstream face of the Coniston GS main dam. The north and south gravity sections are to the left and right of the spillways, respectively.

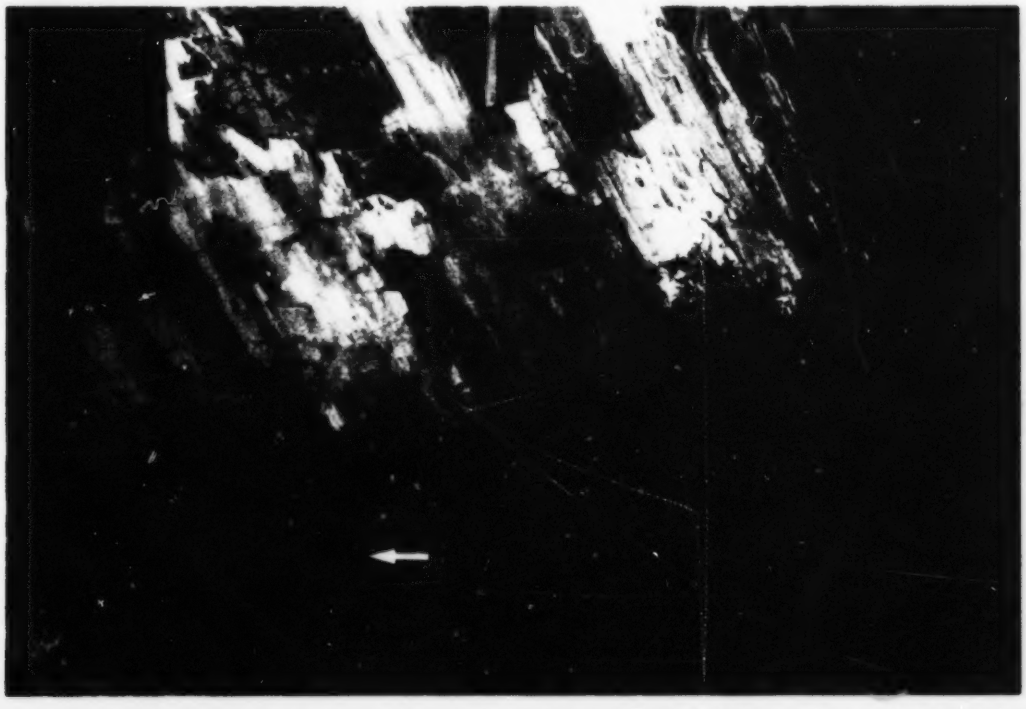

Figure 3 Deteriorated concrete on the north gravity section. The drill hole for Core 1 is indicated in the deteriorated area in the lower left of the figure.

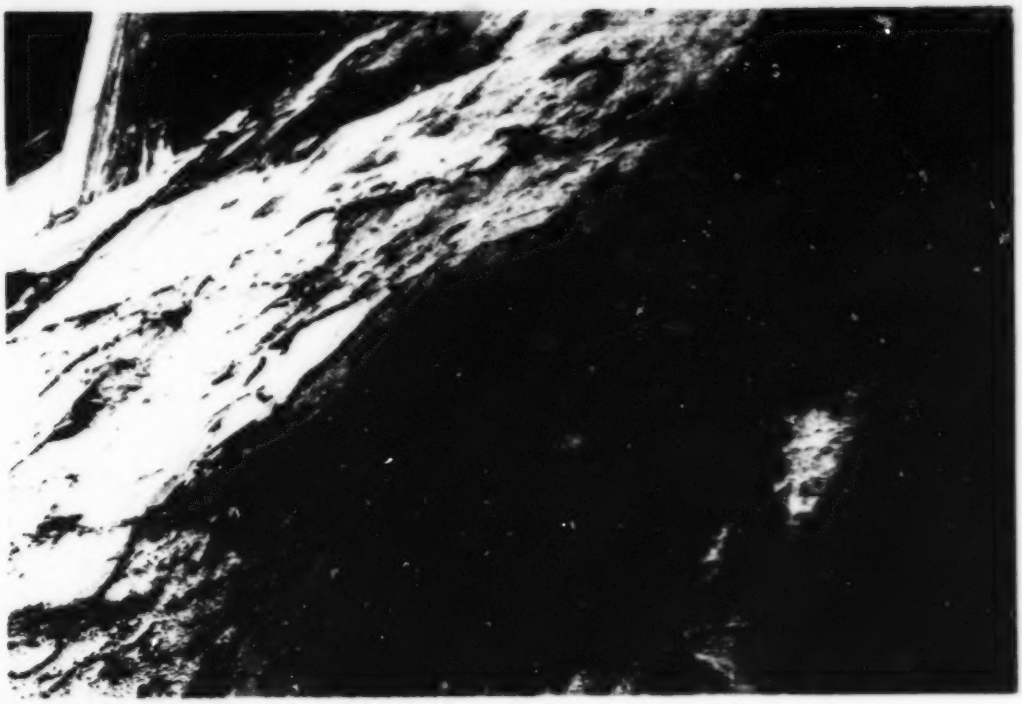

Figure 4 Spalled concrete in the north gravity section at the bulge reported in 1989.

Figure 5 Drilling from the base of the south gravity section.

APPENDIX A

CONISTON GS
CONCRETE CORE LOG

Appendix A

CONISTON GS
CONCRETE CORE LOG

CORE No.	DEPTH IN CORE-HOLE (m)	REMARKS
Core 1	0 - 0.09	- Core recovered as rubble
	0.09 - 0.18	- Core cracked
	0.18 - 1.12	- Sound concrete
- Core (100 mm diameter) drilled from near the base of the north gravity section in an area of deteriorated concrete. - See Figure A1 for the core location and Figure A2 for a photo of the core.		
Core 2	0 - 0.34	- Core cracked
	0.34 - 1.30	- Sound concrete
- Core (100 mm diameter) drilled from near the base of the north gravity section in an area of spalled concrete. - See Figure A1 for the core location and Figure A2 for a photo of the core.		
Core 3	0 - 0.23	- Core recovered as rubble
	0.23 - 1.24	- Sound concrete
- Core (100 mm diameter) drilled from near the base of the north gravity section in an area of spalled concrete. - See Figure A1 for the core location and Figure A2 for a photo of the core.		
Core 4	0 - 0.23	- Core recovered as rubble
	0.23 - 0.38	- Core cracked
	0.38 - 0.81	- Sound concrete
	0.81 - 0.94	- Core recovered as rubble (core intersected 15 mm diameter steel bar)
- Core (100 mm diameter) drilled from near the base of the south gravity section in an area of spalled concrete. - See Figure A1 for the core location and Figure A3 for a photo of the core.		
Core 5	0 - 0.13	- Core recovered as rubble
	0.13 - 0.48	- Core cracked
	0.48 - 1.30	- Sound concrete
- Core (100 mm diameter) drilled from near the base of the south gravity section in an area of spalled concrete. - See Figure A1 for the core location and Figure A3 for a photo of the core.		

CONISTON GS

CONCRETE CORE LOG

CORE No	DEPTH IN CORE HOLE (m)	REMARKS
Core 6	0 - 0.18	- Core recovered as rubble
	0.18 - 0.43	- Core cracked
	0.43 - 0.79	- Sound concrete
	- Core (100 mm diameter) drilled from near the base of the south gravity section in an area of spalled concrete.	
	- See Figure A1 for the core location and Figure A3 for a photo of the core.	
Core 7	0 - 0.50	- Core recovered as rubble
	0.50 - 13.34	- Sound concrete
	10.67	- 15 mm diameter steel bar
	12.93	- Contact between concrete and bedrock
	- Core (100 mm diameter) drilled vertically, 1.80 m from the downstream face of the second pier from the north end of the spillway.	
	- See Figure A1 for the core location and Figure A4 for a photo of the core.	
	- Results of the borehole camera survey:	
	- Crack approx 5 mm wide at 1.3 m	
	- Crack approx 5 mm wide at 3.8 m	
	- Cracked zone approx 20 mm wide at 7.1 m	
	- Cracks present in deck	
Core 8		
	- This core was drilled to provide access for the borehole camera and the core was not retained.	
	- The borehole had a diameter of 76 mm.	
	- Core drilled vertically from the fourth pier from the north end of the main dam.	
	- See Figure A1 for the core location.	
	- Results of the borehole camera survey:	
	- Crack approx 5 mm wide at 4.3 m	
	- Crack approx 15 mm wide at 6.0 m	
	- Crack approx 15 mm wide at 6.4 m	
	- Cracked zone from 6.8 to 6.9 m	
	- Near upper portion of hole, numerous fractured aggregates and hairline cracks were observed.	
Core 9		
	- This core was drilled to provide access for the borehole camera and the core was not retained.	
	- The borehole had a diameter of 76 mm.	
	- Core drilled vertically from the second pier south of the spillway.	
	- See Figure A1 for the core location.	
	- Results of the borehole camera survey:	
	- Crack approx 5 mm wide at 2.7 m	
	- Crack approx 5 mm wide at 3.8 m	
	- Crack approx 5 mm wide at 4.4 m	
	- Cracks present in deck	

CONISTON GS
CONCRETE CORE LOG

CORE No	DEPTH IN CORE HOLE (m)	REMARKS
Core PH1	0 - 0.20 0.20 - 1.35	- Core section consists primarily of mortar - Core consists of mortar and large stones up to 230 mm in size
- Core drilled vertically from the powerhouse floor, 2.40 m from the east access door. - See Figure A5 for a photo of the core.		
Core PH2	0 - 0.25 0.20 - 0.79	- Core section consists primarily of mortar - Core consists of mortar and large stones up to 230 mm in size
- Core drilled vertically from the powerhouse floor between Units 2 and 3. - See Figure A5 for a photo of the core.		

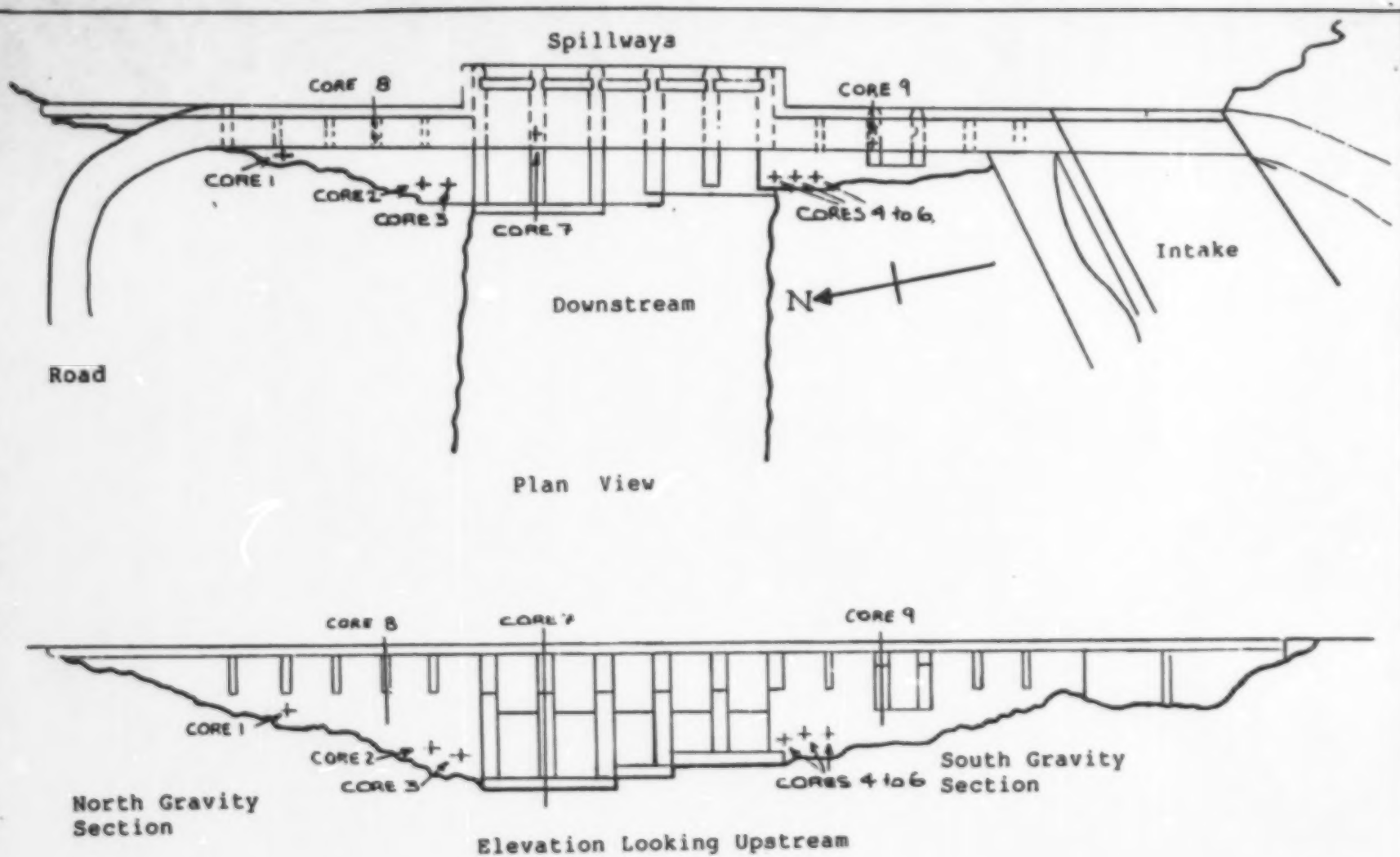

FIGURE A1

CONISTON GS

MAIN DAM

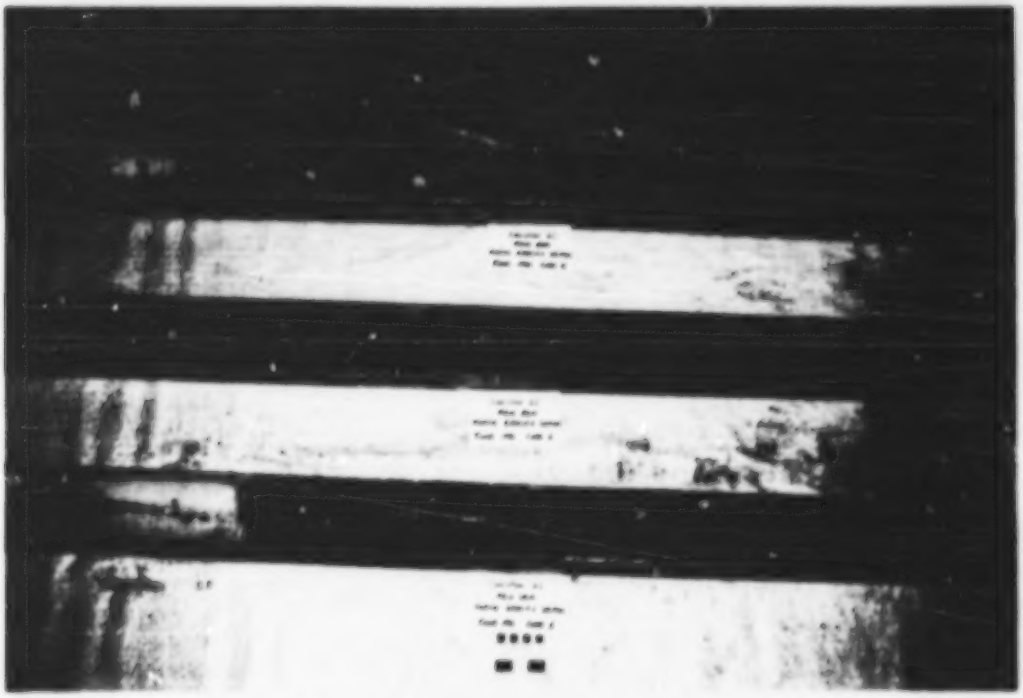

Figure A2 Cores 1 to 3 drilled at right angle to the downstream face of the north gravity section.

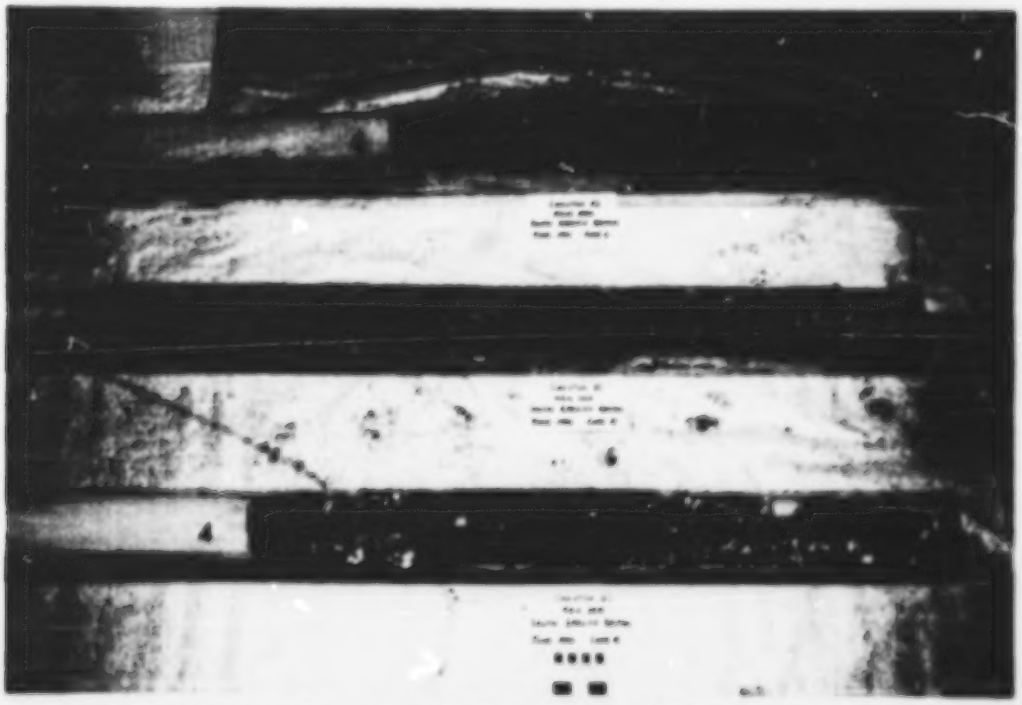

Figure A3 Cores 4 to 6 drilled at right angle to the downstream face of the south gravity section.

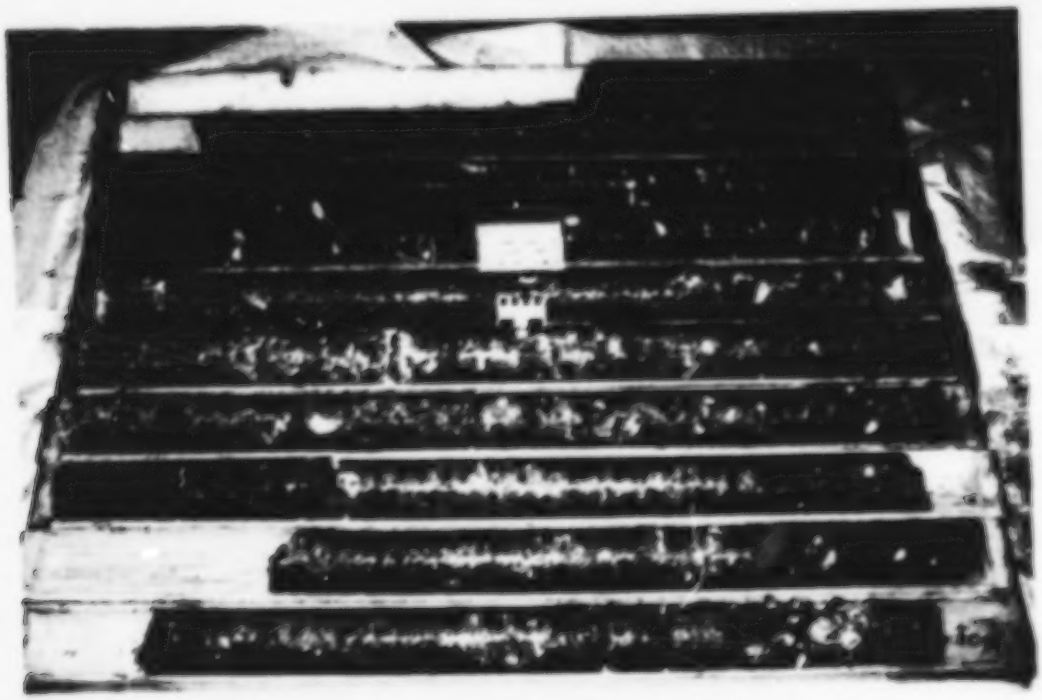

Figure A4 Core 7 drilled vertically from the second pier from the north end of the spillway.

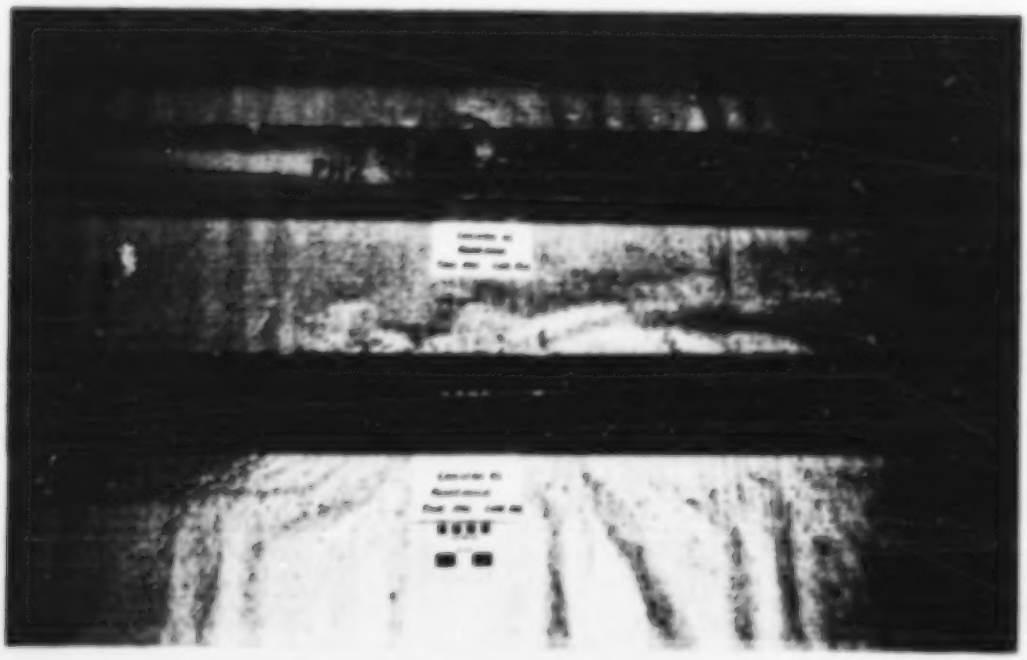

Figure A5 Cores PH1 and PH2 drilled vertically from the powerhouse floor.